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Title: Synoptic/Planetary-Scale Interactions and Blocking Over the North Atlantic Ocean

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Significant Accomplishments in the Past Year

The central theme of this project has been the diagnosis of a major blocking anticyclone and its interacting synoptic-scale circulations that occurred during January 1979 over the North Atlantic Ocean. Foremost among the interacting circulations was an extratropical cyclone that developed explosively 60 to 36 hours prior to the block's first appearance. One segment of our work this past year focused on the diagnosis of this cyclone and, in addition, the diagnosis of a second explosive cyclone development that occurred over the southeastern United States during the time of block formation. The diagnoses have been accomplished using a diagnostic relationship known as the Zwack-Okossi (Z-O) development equation, originally published in quasigeostrophic form in 1986 (Zwack, P., and B. Okossi, 1986: Monthly Weather Review, pp. 655-666). The PI has been collaborating with Dr. Zwack (University of Quebec at Montreal) to formulate an extended form of the Z-O equation that includes non-quasigeostrophic forcing. Results indicate, not surprisingly, that in both cyclone cases the development occurred as a result of the combined favorable influence of positive vorticity advection, warm air advection, and latent heat release and ceased when one or more of these influences diminished. Among the advantages of the Z-O equation is its ability to diagnose the influence of each atmospheric layer on surface development and, thus, fully expose the process synopticians refer to as "upper-air support". This study has revealed that much of the upper-air support occurs above 500 mb (maximum 300-200 mb) through the vorticity and temperature advection terms. Latent heat release maximizes below 500 mb. In addition to its use as a tool for diagnosing low level development, there is yet another dimension to the Z-O equation. It also provides near-surface height tendencies available for use as a lower boundary condition for the height tendency equation. This has been applied to upgrade height tendency estimates previously obtained for the over-water case and is described in a manuscript recently submitted to Tellus.

A second segment of our work has been the continued comparison of the SAT and NOSAT versions of the Goddard Laboratory for Atmospheres (GLA) 4° lat by 5° lon FGGE analyses. The comparison strategy has been to examine correlation coefficients, RMS differences, and standard deviations first for

basic variable fields (e.g., geopotential height, temperature, wind speed) and then for higher-order derived parameters (e.g., gradient magnitudes, advections, vorticity, height tendencies). In all cases basic variable fields exhibit very high correlations (typically greater than 0.95), suggesting only subtle differences in the basic patterns given by the two analysis sets. However, RMS differences are as high as 30% of the basic variability of the fields, indicating that more significant point-to-point differences do occur. These differences then lead to decreased correlations as increasingly higher-order parameters are considered.

Focus of Current Research and Plans for Next Year

The present focus is on the completion of the two tasks identified in the previous section and the submission of appropriate journal manuscripts. In the coming year we expect to test the sensitivity of the Z-O equation results to second-order differencing by repeating some of the calculations using fourth-order differencing. In addition, we expect to examine the surface anticyclone development that occurred beneath the upper-air blocking event.

Publications

1. Refereed

Fosdick, E.K., and P.J. Smith, 1991: Latent heat release in an extratropical cyclone that developed explosively over the southeastern United States. Monthly Weather Review, 119, 193-207.

Uhl, M.A., P.J. Smith, and A.R. Lupo, 1991: The diagnosis of a pre-blocking explosively-developing extratropical cyclone system. Submitted to Tellus.

2. Non-Refereed

The following papers were presented by the PI and appear in the Preprint Volume of the First International Symposium on Winter Storms, January 14-18, 1991, New Orleans, LA.

Smith, P., A. Lupo, and P. Zwack: Diagnosing Development, Part II: A Study of Rapid Cyclone Development Using Analyzed Data Fields.

Smith, P., and R. Knabb: A Diagnosis of Vorticity Fields Associated with an Explosively-Developing Winter Cyclone over the Southeastern United States.

3. M.S. Thesis

Lupo, Anthony R.: A Diagnosis of the Explosive Development of Two Extratropical Cyclones (May 1991).